# Combinatorial Optimization
# Overview

Prof. Dr. Norbert Trautmann

University of Bern

Fall semester 2025

(as of September 3, 2025)

# Outline

# Outline

# CV Norbert Trautmann



- Born in Karlsruhe (Germany)
- MSc in Industrial Engineering (1997, University of Karlsruhe); Erasmus study year at HEC and EPF Lausanne
- PhD in Business Administration (2000, University of Karlsruhe) and Habilitation (2004, University of Karlsruhe)
- Since 2005: Professor in Quantitative Methods in Business Administration, Department of Business Administration, University of Bern
- Research:
  - Mathematical programming
  - Operations management
  - Portfolio selection

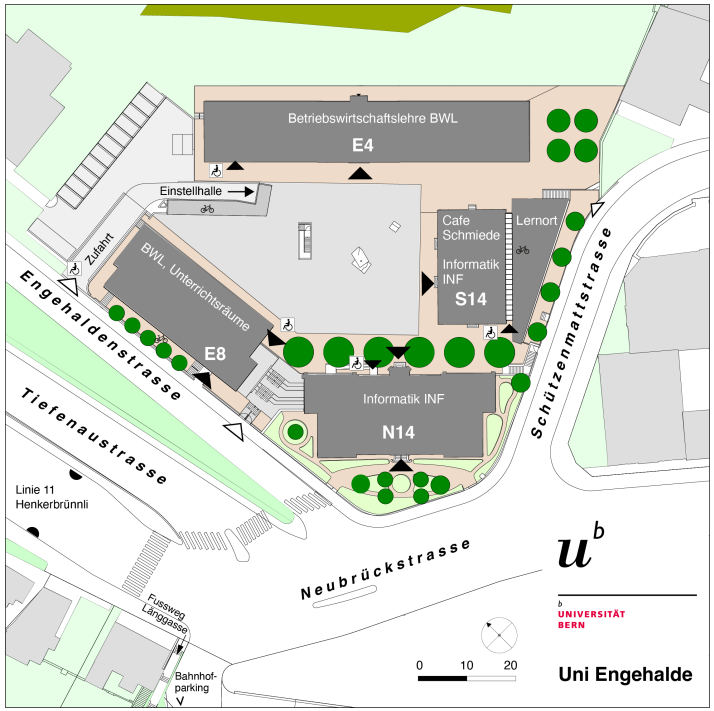
# CV Nicklas Klein



- Born in Herten (Germany)
- MSc in Business Mathematics (2021, University of Dortmund)
- PhD in Business Administration (2025, University of Bern)
- 2023/24: Research Stay at Rutgers University (NJ) and NYU Stern School of Business (NY)
- Since 2025: Postdoctoral Researcher in Operations Research, Department of Business Administration, University of Bern
- Research:
  - Combinatorial optimization
  - Project management
  - Scheduling

# Contact

- Department of Business Administration: Group for Business Analytics, Operations Research and Quantitative Methods
- Engehaldenstrasse 4, 3012 Bern
  - Office 206 (NK)
  - Office 207 (NT)
- http://www.pqm.unibe.ch
- Questions concerning this course
  - Content: ILIAS forum
  - Organization: co.pqm@unibe.ch



# Outline

# Course in context of master studies

- Part of the MSc courses in Business Administration
- Course can be selected as component of
  - MSc BA: Management Science module or Elective module
  - MSc B&Ec: elective courses in BA
- 4.5 ECTS
- Required knowledge
  - Introduction to Mathematics
  - Quantitative Methods in Business Administration
- KSL registration required for
  - course participation
  - access to ILIAS course

# Flipped Classroom I

Online learning units (ILIAS): available Thursday[1] from 7 AM

- Screencast video
  - Focus: basics, modeling techniques, algorithms
  - Self-study using slides and optimization software files
- Exercise series
  - Self-study completion
  - Sample solution
- Additional literature (library): textbook, case study articles

AMPL software

- Download: ILIAS
- Introduction video series available from Sep 25

[1] exception: Oct 23

# Flipped Classroom II

In-person lectures: Monday[2] 10:15–12:00

- Main building, room 114
- 10:15–11:00: lecture
  - Discussion of screencast content
  - Presentation of snapshot cases
  - Live-voting; summary in ILIAS
- 11:15–12:00: exercises
  - Discussion of exercise series
  - Discussion of bonus exercises (see below)

Further questions concerning course content: ILIAS forum

[2] exception: Oct 27

# Flipped Classroom III



Bonus exercises

- In total, eight assignments between Sep 22 and Nov 17
- Submission of solutions by groups of two students
- How and when to submit: last page of assignment
- Grading: in total, 10 bonus points can be achieved
- Questions
  - Forming groups: co.pqm@unibe.ch
  - Sample solution: in-person lecture or ILIAS forum
  - Grading: co.pqm@unibe.ch

# Outline

# Overview exam

- Written exam
- 90 points in total, 7–9 assignments
  - Relevant: entire course content
  - Two assignments: 8–12 single-choice questions
  - Remaining assignments: style of exercise series and bonus exercises
  - Questions about AMPL (e.g., correcting errors in given code)
- Permitted aids: hand-held calculator and provided formulary
- Grading
  - Grading based on total points achieved in exam (max. 90 points) and bonus exercises (max. 10 points)
  - At most 90 points required for grade 6.0
  - 2025 bonus points can be credited to exams in Dec 2025 and Feb 2026

# Dates for final exam

- Dates (duration of final exam is 90 minutes)
  1. Monday, Dec 15, 2025; begin at 10:15 AM
     - Registration (only via KSL) by Nov 30, 2025
     - Deregistration (only via KSL) by Dec 13, 2025
     - Access of graded exam: Dec 19, 2025 or Jan 5, 2026
  2. Tuesday, Feb 10, 2026; begin at 2:15 PM
     - Registration (only via KSL) by Jan 31, 2026
     - Deregistration (only via KSL) by Feb 8, 2026
     - Access of graded exam: Feb 13, 2026 or Feb 16, 2026
- Location: will be announced on ILIAS after closing date for exam deregistration
- Sample exam questions: in-person lecture Dec 1, 2025
- Q&A via ILIAS forum until Dec 8, 2025

# Outline

# Learning outcomes



## The students are able to

- efficiently model complex decision problems in finance, marketing, and management as linear programs (LP) or mixed-integer linear programs (MILP)
- implement and solve the respective programs with industrial solvers, and analyze the results obtained
- describe the structural properties of LP and of MILP
- analyze the solution procedures applied by the solvers (i.e., the simplex algorithm for LP and the branch-and-bound and the branch-and-cut-algorithm for MILP)
- select and apply basic heuristic algorithms to solve combinatorial optimization problems (CO)
- develop and implement MILP-based heuristics for solving CO
- explain basic meta-heuristic algorithms for solving CO

# Structure



1. Linear programming and the Simplex algorithm
2. Exact methods for MILP
   - Branch-and-bound method
   - Cutting planes
   - Application: The Enchanted Journey
3. Traveling salesperson and vehicle routing problems
   - MILP formulations
   - Heuristics
   - Applications: UPS, Coca-Cola Enterprises
4. Heuristics for CO
   - MILP-based heuristics
   - Metaheuristics
   - Application: iHeartMedia

# Overview

# Literature


**Hillier Lieberman (2024): Introduction to Operations Research. McGraw-Hill**

Neumann Morlock (2002): Operations Research. Hanser

Brandindu Trautmann (2014): A mixed-integer linear programming approach to the optimization of event-bus schedules: a scheduling application in the tourism sector. Journal of Scheduling 17(6), 621–629

Kant Jacks Aantjes (2008): Coca-Cola Enterprises optimizes vehicle routes for efficient product delivery. Interfaces 38(1), 40–50

Holland Levis Nuggehalli Santilli Winters (2017): UPS optimizes delivery routes. Interfaces 47(1), 8–23

Venkatachalam Wong Uyar Ward Aggarwal (2015): Media company uses analytics to schedule radio advertisement spots. Interfaces 45(6), 485–500